ALABAMA - HAZARDS ANALYSIS AND SLOSH DOCUMENTATION

PURPOSE

The purpose of the hazards analysis is to quantify the wind speeds and still-water surge heights for hurricanes that have a reasonable meteorological probability of occurring in the study area. Freshwater flooding from heavy rainfall accompanying hurricanes is an additional hazard which must be considered.

The primary objective of the hazards analysis is to determine the probable worst-case effects from hurricanes of various intensities that could strike the region. For the purposes of this study, the term worst-case is used to describe the peak surges and wind speeds that can be expected at all locations within the study area without regard to hurricane track.

FORECASTING INACCURACIES

The worst-case approach is used in the hazards analysis because of inaccuracies in forecasting the precise tracks and other parameters of approaching hurricanes. The National Hurricane Center has made an analysis of hurricane forecasts to determine the normal magnitude of error. The average error in the official 24-hour hurricane track forecast is over 100 statute miles left or right of the forecast track.

The average error in the official 24-hour wind speed forecast is 15 miles per hour (mph), and the average error in the 12-hour official forecast is about 10 mph. Hurricane evacuation decision-makers should note that an increase of 10 to 15 mph can easily raise the intensity value of the approaching hurricane one category on the Saffir/Simpson Hurricane Scale, which is discussed in the following paragraph. Other factors may work to increase apparent hurricane surge heights above the potential heights calculated by the SLOSH model. Because of these forecast and modeling inaccuracies, public officials who are faced with an imminent evacuation should consider preparing for a hurricane at landfall that may be one category above the forecast strength.

SAFFIR/SIMPSON HURRICANE SCALE

One of the earlier guides developed to describe the potential storm surge generated by hurricanes is the Saffir/Simpson Hurricane Scale. Herbert Saffir, Dade County, Florida, Consulting Engineer, and Dr. Robert H. Simpson, former Director of the National Hurricane Center developed the Saffir/Simpson scale. The National Hurricane Center has added a range of central barometric pressures associated with each category of hurricane described by the Saffir/Simpson Hurricane Scale. A condensed version of the Saffir/Simpson Hurricane Scale with the barometric pressure ranges by category is shown in Table 1. The related damage potential of each hurricane category is described in Table 2.

TABLE 1
SAFFIR/SIMPSON HURRICANE SCALE

	Central Pressure		Winds		Damage
Category	Millibars	Inches	(mph)	(kts)	
1	>980	>28.9	74-95	64-83	Minimal
2	965-979	28.5-28.9	96-110	84-96	Moderate
3	945-964	27.9 - 28.5	111-130	97-113	Extensive
4	920-944	27.2 - 27.9	131-155	114-135	Extreme
5	< 920	<27.2	>155	>135	Catastrophic

TABLE 2
SAFFIR/SIMPSON HURRICANE CATEGORY DAMAGE SCALE

Category 1. Winds of 74 to 95 miles per hour. Damage primarily to shrubbery, trees, foliage, and mobile homes. No real wind damage to other structures. Some damage to poorly constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.

Category 2. Winds of 96 to 110 miles per hour. Considerable damage to shrubbery and tree foliage; some trees blown down. Major damage to exposed mobile homes. Extensive damage too poorly constructed signs. Some damage to roofing materials of buildings; some window and door damage. No major wind damage to buildings. Considerable damage could occur to piers. Marinas flooded. Small craft may be torn from moorings.

Category 3. Winds of 111 to 130 miles per hour. Foliage torn from trees; large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings; some window and door damage. Some structural damage to small buildings. Mobile homes destroyed. Serious flooding at coast and many smaller structures near coast destroyed; larger structures near coast damaged by battering waves and floating debris.

Category 4. Winds of 131 to 155 miles per hour. Many shrubs and trees are blown down and most street signs are damaged. Extensive damage to roofing materials, windows, and doors. Complete failure of roofs on many small residences. Complete destruction of mobile homes. Major damage to lower floors of structures near shore due to flooding and battering by waves and floating debris. Major erosion of beaches.

Category 5. Winds greater than 155 miles per hour. Shrubs and trees are blown down; considerable damage to roofs of buildings and all signs are damaged or destroyed. There would be very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings. Extensive shattering of glass in windows and doors would occur. Some complete building failures. Small buildings overturned or blown away. Complete destruction of mobile homes.

STORM SURGE

a. Introduction

Storm surge is the abnormal rise in water level caused by wind and pressure forces of a hurricane. Storm surge produces most of the flood damage and drowning associated with tropical storms. A numerical storm surge model has been applied to the Mobile Bay area. The model calculates sea, lake and overland surges from hurricanes and has the acronym "SLOSH."

The output of SLOSH-model provides heights of storm surge for various combinations of hurricane strength, forward speed of storm, and direction of storm. Strength is modeled by use of the central pressure and storm eye size using the five categories of storm intensity. Nine storm-track headings and three speeds were selected as being representative of storm behavior in this region.

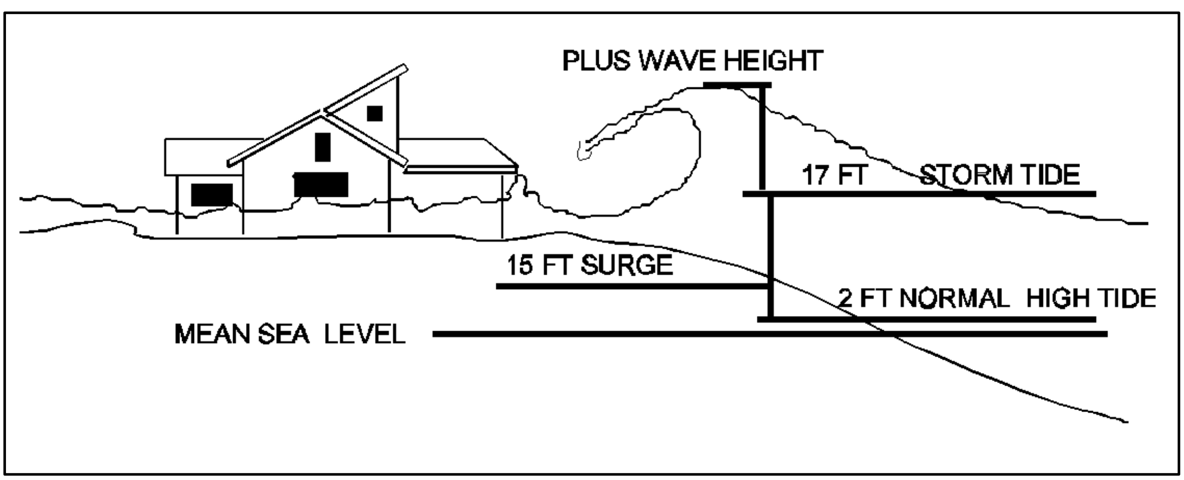
Various storm events can cause abnormally high water levels along ocean coasts and interior shorelines. These higher than expected water levels, known as storm surges, are generally the result of a synoptic scale meteorological disturbance. Storm surges can affect a shoreline over distances of more than 100 miles; however, there may be significant spatial variations in the magnitude of the surge due to local bathymetric and topographic features. Wind is the primary cause of storm surge. Wind blowing over the surface of the water exerts a horizontal force that induces a surface current in the general direction of the wind. The surface current, in turn, forms currents in subsurface water. In the case of a hurricane, the depth affected by this process of current creation depends upon the intensity and forward motion of the storm. For example, a fast-moving hurricane of moderate intensity may only induce currents to a depth of a hundred feet, whereas a slow moving hurricane of the same intensity might induce currents to several hundred feet. As the hurricane approaches the coastline, these horizontal currents are impeded by a sloping continental shelf, thereby causing the water level to rise. The amount of rise increases shoreward to a maximum level that is often inland from the usual coastline.

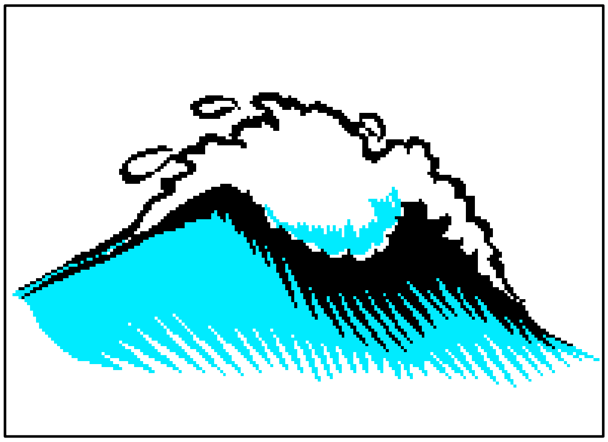
b. Factors Affecting Surge Height

The elevation reached by the storm surge within a coastal basin depends upon the meteorological parameters of the hurricane and the physical characteristics existing within the basin. The meteorological parameters affecting the height of the storm surge include the intensity of the hurricane, measured by the storm-center sea-level pressure, track (path) of the storm, forward speed, and radius of maximum winds. Due to the complementary effects of forward motion and the counterclockwise rotation of the wind field, highest surges from a hurricane usually occur on the northeast quadrant of the storm's track. This radius of maximum winds, which is measured from the center of the hurricane eye to the location of the highest wind speeds within the storm, can vary from as little as 4 miles to as much as 50 miles or greater. Peak storm surge may vary drastically within a relatively short distance along the coastline depending on the radius of maximum winds and the point of hurricane eye landfall. The physical characteristics of a basin that influence the surge heights include the basin bathymetry (water depths), roughness of the continental shelf, configuration of the coastline, and natural or man-made barriers. A wide, gentle sloping continental shelf or a large bay may produce particularly large storm surges.

c. Total Flood Elevation

Other factors that contribute to the total water height are the initial water level within the basin at the time the hurricane strikes and wave effects. Storm surge is defined as the difference between the observed water level and the normal astronomical tide. Any astronomical tide level above the mean is additive to the storm surge. The timing of the arrival of storm surge is important in that the difference in total flood elevation can be as much as 1 to 2 feet in the study area.





Waves breaking near the shore cause a transport of water shoreward. When there is an increase in wave height water cannot flow back to the sea as rapidly as it came in. This phenomenon, known as "wave setup", increases the water level along the beachfront. Waves will break and dissipate their energy in shallow water. Therefore, a relatively steep offshore beach slope allows large ocean waves to get closer to the shore before breaking and usually promotes larger waves. Wave setup is primarily a concern near the beachfront because waves are generally not transmitted inland of the coastline even if the beach has been overtopped.

THE SLOSH COMPUTER MODEL

a. General

The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model was developed by the National Weather Service to calculate potential surge heights from hurricanes. Jelesnianski and Taylor developed the hurricane model, which drives the storm surge model. The SLOSH model is used for real-time forecasting of surges from approaching hurricanes within selected Gulf and Atlantic coastal basins. In addition to computing surge heights for the open coast, the SLOSH model has the added capability to simulate the routing of storm surge into sounds, bays, estuaries, and coastal river basins, as well as calculating surge heights for overland locations. Significant natural and manmade barriers are represented in the model and their effects simulated in the calculations of surge heights within a basin.

The SLOSH model uses time-dependent meteorological data to determine the driving forces of a simulated storm. These data are as follows:

(1) Central barometric pressure at 6-hour intervals.

(2) Latitude and longitude of storm positions at 6-hour intervals.

(3) The storm size measured from the center (eye) to the region of maximum winds. Wind speed is not an input parameter, since the model calculates a wind-field for the modeled storm based on meteorological input parameters.

The height of the water surface well before the storm directly affects the area of interest is also required. This initial height is the observed water surface height occurring about two days before storm arrival. Astronomical high tide was not set in the model.

The values or functions for the coefficients within the SLOSH model are generalized to serve for modeling all storms within all basins and are set empirically through comparisons of computed and observed meteorological and surge height data from numerous historical hurricanes. The coefficients are a function of differing storm parameters and basin characteristics. Calibration of the model based on a single storm event within a basin is avoided since there is no guarantee that the same coefficient values will serve as well for other storms.

b. Mobile Bay SLOSH Grid

Figure 1 illustrates the area covered by the grid for the Mobile Bay SLOSH model. The area covered by the grid is called a "basin"--the "Mobile Bay Basin." The grid is a telescoping hyperbolic coordinate system with 115 arc lengths and 68 radials. This type grid is used to put more grid cells over land for better surge delineation but still have a large water body covered for adequate calculations.

The telescoping grid provides a large geographical area with detailed land topography. The smallest grid represents an area of about 0.1 square miles. This permits inclusion of topographic details such as highway and railroad embankments, causeways, levees, etc. The largest grid cell is about 1.3 square miles. The grid is tangent to the earth at 30E45'N and 88E08'W. The basin center is located at 30E42'10"N and 87E59'30"W.

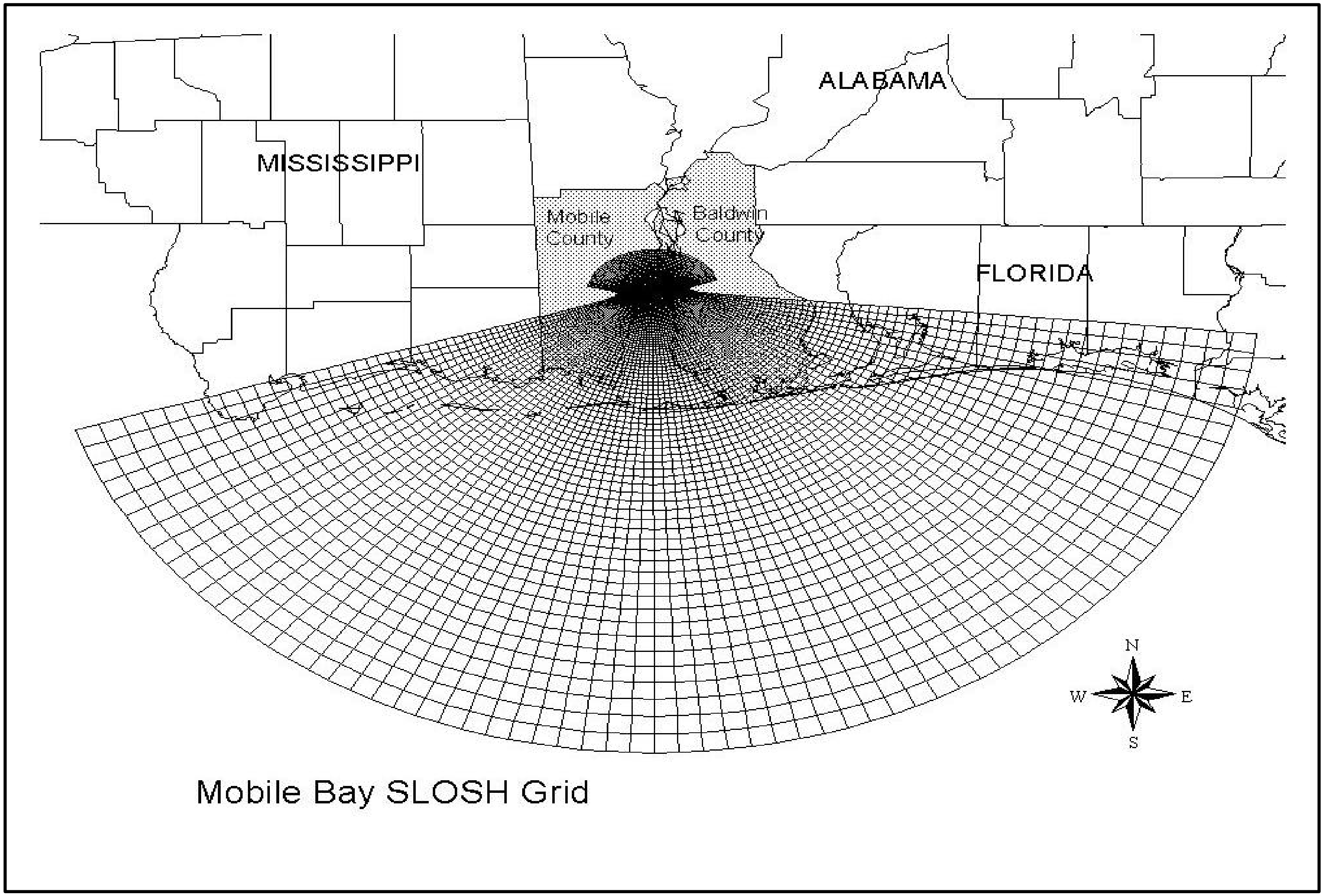
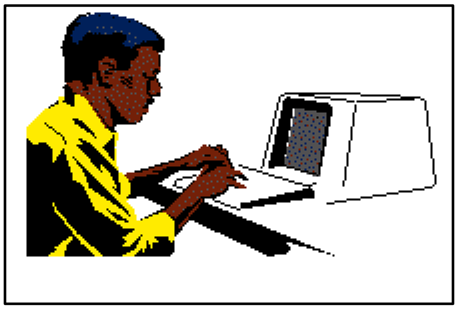


FIGURE 1 MOBILE BAY SLOSH GRID

c. Verification of the Model



After a SLOSH model has been constructed for a coastal basin, verification is conducted with real-time runs of historical storms. The computed surge heights are compared with those measured from historical storms and, if necessary, adjustments are made to the input or basin data. In instances where the model has given realistic results in one area of a basin, but not in another, closer examination has often revealed inaccuracies in the representation of barrier heights or missing values in bathymetric or topographic data. The hurricanes used to verify the Mobile Bay SLOSH Model were Hurricanes Opal and Georges.

THE MOBILE BAY MODELING PROCESS

A total of 1815 hypothetical hurricanes were run through the Mobile Bay SLOSH Model. The characteristics of the simulated hurricanes were determined from an analysis of historical hurricanes. The selected storms varied in intensities, forward speeds and approach directions. The 1815 storms are summarized in Table 3 and graphically presented on Plates 1 - 9 at the end of this document. The simulated hurricanes included Category 1 through Category 5 hurricane intensities and nine approach directions. Forward speeds of 5, 15 and 25 miles per hour were used. The radius of maximum winds specified for all the simulated hurricanes at landfall was 25 miles.

TABLE 3
MOBILE BASIN HYPOTHETICAL STORM SCENARIOS

Direction	Speed (mph)	Intensities	Tracks	Runs	MEOWS
W	5, 15, 25	Cat. 1-5	11	165	15
WNW	5, 15, 25	Cat. 1-5	15	225	15
NW	5, 15, 25	Cat. 1-5	14	210	15
NNW	5, 15, 25	Cat. 1-5	17	255	15
N	5, 15, 25	Cat. 1-5	17	255	15
NNE	5, 15, 25	Cat. 1-5	14	210	15
NE	5, 15, 25	Cat. 1-5	13	195	15
ENE	5, 15, 25	Cat. 1-5	10	150	15
E	5, 15, 25	Cat. 1-5	10	150	15
			TOTAL	1815	135

After making landfall, most hurricanes weaken because the central pressure and radius of maximum winds increase. This was taken into account in modeling each of the storm tracks. The initial sea surface height set in the Mobile Bay SLOSH model was 1.25 foot. This initial height, known as tide anomaly, represents the height of the water surface above M.S.L. existing several days in advance of approaching hurricanes. Furthermore, to simulate conditions at high tide, an additional .75 foot was included. Thus all SLOSH runs of hypothetical hurricanes were supplied with initial datum of 2.0 feet M.S.L., and the resulting calculations of storm surge represent conditions at time of high tide.

MAXIMUM ENVELOPES OF WATER (MEOWS)

The maximum surge in the affected area is called the peak surge. The location of the peak surge depends on where the eye of a hurricane crosses the coastline, storm intensity, shape of the coastline, the approach direction, and the radius of maximum winds. The peak surge from a hurricane usually occurs to the right of the storm path and within a few miles of the radius of maximum winds.

Due to the inability to precisely forecast the landfall location for a hurricane, the National Hurricane Center developed MEOWs (Maximum Envelopes of Water). A MEOW stores the maximum water surface elevation in each grid cell for all the hurricane tracks in one direction for a particular forward speed, and storm intensity. There are 135 MEOWs for the Mobile Bay SLOSH Basin.

The results of the 135 original MEOWs were analyzed to determine which changes in storm parameters (i.e., intensity, approach speed, and approach direction) resulted in the greatest differences in the values of the peak surges for all locations and those that could reasonably be combined to facilitate evacuation decision-making. Changes in storm category accounted for the greatest change in peak surge heights. Therefore, the National Hurricane Center was asked to compile groups of MEOWs by category.

The National Hurricane Center subsequently created MOMs (MEOWs of MEOWs) which eliminate consideration of hurricane approach speed and direction but maintaining the separation of categories 1, through 5 storms. The MOMs basically represent the maximum water surface elevation for each grid cell regardless of approach direction, forward speed or track. The MOMs were used to develop the hurricane surge maps. These hurricane surge inundation maps depict maximum storm surge heights that could be generated by the five hurricane categories, without regard to approach speed, direction, or track.

TIME-HISTORY POINT DATA

The time-history information produced by the SLOSH model includes still-water surge heights, wind speeds, and wind direction at 30-minute intervals for 72 hours. Emergency Management Directors selected time history points for key locations in their county. They are located at low-lying roads and bridges that would be critical to an evacuation, at potentially vulnerable population centers, or at significant natural or manmade barriers. Figures 2 and 3 show the location of time history points for each coastal County. Tables 4 and 5 show the maximum surge heights for each time history point for the category 1 through 5 hurricane.

The purpose of the time-history data is to determine the pre-landfall hazard distances for each of the counties within the study area. Pre-landfall hazard distance is the distance from the eye of an approaching hurricane to each jurisdiction at the time an evacuation would be curtailed by hazardous weather conditions. This distance must be accounted for in timing evacuation decision-making. For this Hurricane Evacuation Study, two specific conditions were evaluated: the arrival of sustained gale-force winds (34-knot sustained wind speed, 1-minute average) and the onset of storm surge inundation of low-lying roads, bridges, or other critical areas. The first of these two conditions to occur determines the pre-landfall hazard distance.

The time of arrival of sustained tropical storm winds is one selected goal for completing an evacuation because high-profile vehicles and vehicles pulling campers or boats could easily be overturned, especially on high-rise bridges. Such an accident would most certainly cripple or halt traffic flow on that evacuation route. The arrival of sustained tropical force winds is also the time, under the majority of hurricane threats, when heavy rainfall begins. Generally, one-half of the total amounts of rainfall received from a hurricane occur from the arrival of sustained tropical storm winds until the eye reaches the coastline.

Storm surge inundation is the other condition limiting evacuation, but should not be a significant factor in most of the study area prior to the arrival of sustained tropical storm winds. The lowest roadway elevations in the study area should be considered when determining the pre-landfall hazard distance. As discussed previously, evacuation decision-making officials should be aware that the coincidental occurrence of astronomical high tide and rising storm surge could cause moderate flooding in low-lying areas, particularly on causeways, prior to the arrival of sustained tropical storm winds.

FIGURE 2 MOBILE COUNTY TIME HISTORY POINTS

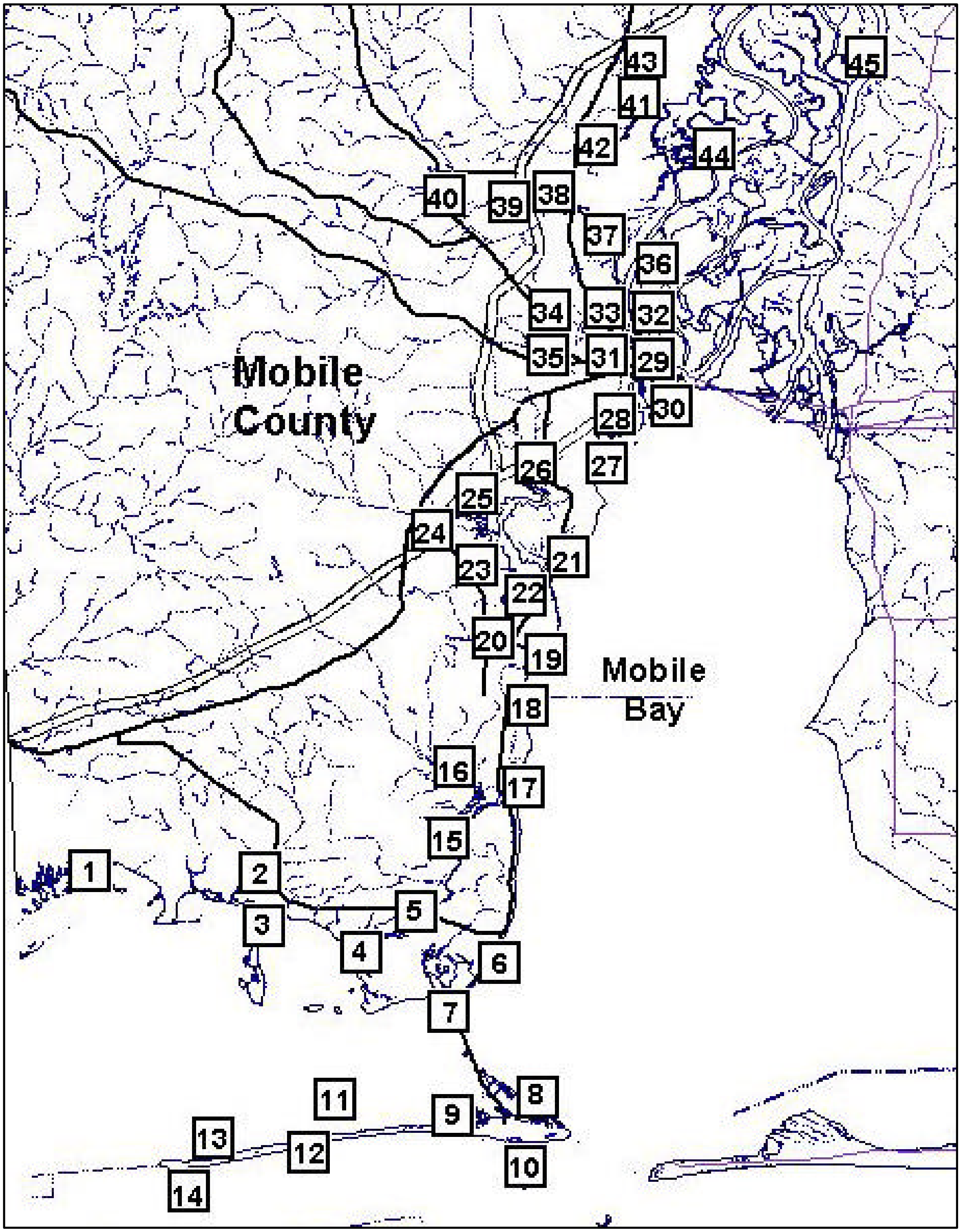


FIGURE 3 BALDWIN COUNTY TIME HISTORY POINTS

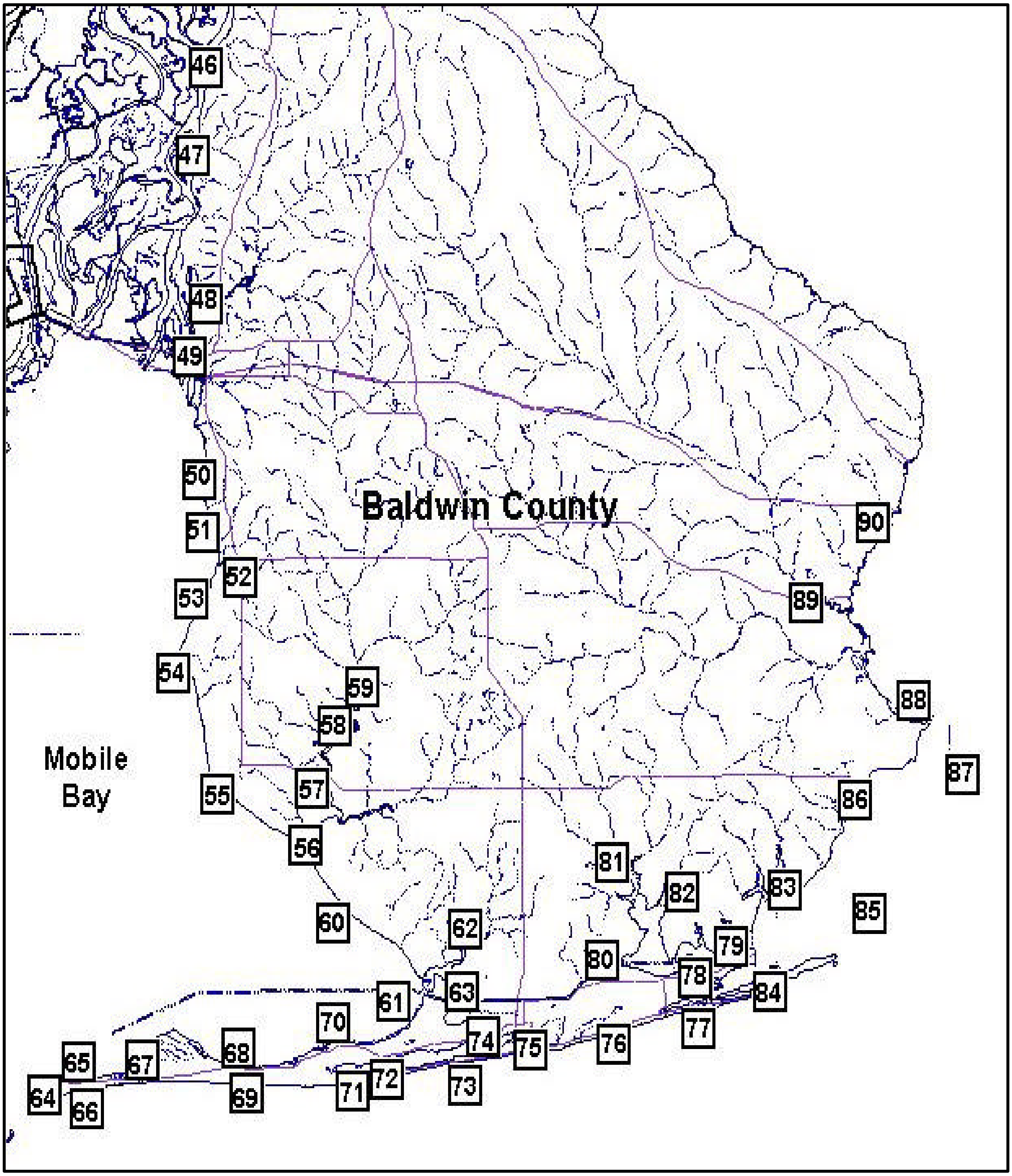


TABLE 4
MOBILE COUNTY TIME HISTORY POINTS

SURGE HEIGHTS ABOVE M.S.L. BY STORM CATEGORY HURRICANE EVENT						
TIME HISTORY POINT	NAME	CAT1	CAT2	CAT3	CAT4	CAT5
1	GRAND BAY	7.7	13.0	17.0	20.4	23.1
2	BAYOU LA BATRE	7.7	12.7	17.0	20.1	23.3
3	CODEN	7.3	12.3	16.4	19.7	22.5
4	FOWL RIVER BAY	7.0	11.3	14.9	18.0	20.7
5	WEST FOWL RIVER	6.9	11.1	14.2	17.1	20.4
6	HERON BAY	5.1	8.1	11.6	14.6	17.4
7	CEDAR POINT	5.8	9.0	12.1	15.0	17.6
8	LITTLE DAUPHIN ISLAND	4.5	7.0	10.0	12.6	14.9
9	DAUPHIN ISLAND AIRPORT	5.3	8.1	11.0	13.5	15.9
10	DAUPHIN ISLAND, GULF SIDE	5.3	7.5	10.1	12.4	14.6
11	NEW DEVELOPMENT, SOUND SIDE	5.7	8.6	11.6	14.3	16.9
12	NEW DEVELOPMENT, GULF SIDE	5.6	8.0	10.9	13.4	16.1
13	WEST DAUPHIN ISLAND, SOUND SIDE	5.4	8.2	11.1	13.6	16.1
14	WEST DAUPHIN ISLAND, GULF SIDE	5.3	7.8	10.4	12.8	15.2
15	DELCHAMPS	5.7	9.0	12.9	16.6	19.3
16	SOUTH ORCHARDS/FOWL RIVER	6.0	9.5	14.0	17.2	20.2
17	MON LOUIS	5.9	9.2	13.2	16.9	20.1
18	BELLEFONTAINE	6.3	9.8	13.9	17.8	20.9
19	DEER RIVER ENTRANCE	6.4	10.1	14.0	18.0	21.1
20	DEER RIVER	6.6	10.3	14.4	18.2	21.5
21	DOG RIVER ENTRANCE	6.7	10.4	14.3	18.1	21.6
22	HOLLINGERS ISLAND	6.5	10.5	14.4	18.2	21.7
23	MANN	6.6	10.5	14.5	18.3	21.9
24	HALLS MILL CREEK	6.8	10.5	14.5	18.5	22.4
25	LLOYDS	7.0	10.6	14.6	18.5	22.8
26	NESHOTA	7.0	10.5	14.4	18.3	23.0
27	MCDUFFIES ISLAND	7.2	10.9	14.8	18.3	22.8
28	GARROWS BEND	7.2	10.9	14.8	18.3	22.7
29	CHOCTAW POINT	7.1	10.8	14.6	18.3	22.7
30	BANKHEAD TUNNEL, WEST ENTRANCE	6.9	11.2	14.4	18.5	22.8
31	BANKHEAD TUNNEL, EAST ENTRANCE	6.9	10.5	14.4	18.5	22.8
32	STATE DOCKS	6.7	10.2	14.6	18.7	23.0
33	PRICHARD	6.7	10.2	14.6	18.7	23.1
34	THREE MILE CREEK	6.0	10.3	14.7	18.8	23.1
35	CHANNEL	6.6	10.2	14.6	18.7	23.0
36	BLAKELEY ISLAND	6.7	10.1	14.7	18.8	23.2
37	CHICKASAW	6.6	9.5	14.8	19.0	23.3
38	CHICKASAW CREEK POINT #1	6.7	9.6	14.9	19.2	24.5
39	CHICKASAW CREEK POINT #2	6.6	9.5	16.1	19.3	23.3
40	CHICKASAW CREEK POINT #3	99.9	99.9	13.7	16.9	19.8
41	SARALAND	6.5	10.0	14.8	19.1	24.0
42	SATSUMA	6.6	9.8	14.7	19.0	23.9
43	CREOLA	6.7	9.8	14.9	19.0	24.1
44	BIG BAYOU CANOT & RR BRIDGE	6.6	9.9	14.6	18.9	23.3
45	SIZEMORE LANDING	6.4	9.3	14.4	18.7	24.8

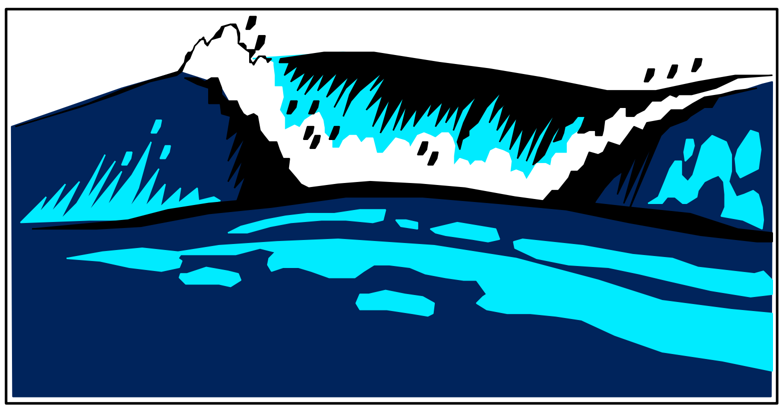
TABLE 5
BALDWIN COUNTY TIME HISTORY POINTS

SURGE HEIGHTS ABOVE M.S.L. BY STORM CATEGORY HURRICANE EVENT						
TIME HISTORY POINT	NAME	CAT1	CAT2	CAT3	CAT4	CAT5
46	HURRICANE LANDING	6.5	9.6	14.5	18.8	24.9
47	GRAVINE ISLAND	6.6	9.9	14.5	18.7	23.3
48	BAY MINETTE	7.1	11.1	14.9	18.1	21.9
49	BRIDGEHEAD	7.3	11.4	14.6	17.9	21.6
50	DAPHNE	6.9	10.1	13.5	16.9	20.4
51	MONTROSE	6.6	9.8	12.9	16.2	19.9
52	FAIR HOPE	6.5	9.8	12.7	16.0	19.8
53	MAGNOLIA BEACH	6.2	9.4	12.3	15.4	19.4
54	POINT CLEAR	5.9	8.7	11.7	14.8	18.5
55	MULLET POINT	5.7	8.1	10.8	14.3	18.1
56	FISH RIVER POINT	6.2	8.9	12.3	15.1	19.1
57	WEEKS BAY	5.6	9.5	13.2	17.2	21.8
58	RIVER PARK	5.9	7.5	9.8	12.2	14.2
59	MARLOW	6.2	7.9	10.5	12.9	14.9
60	CYPRESS POINT	6.4	9.6	12.8	15.0	18.1
61	BON SECOUR BAY @ I.C.W.	6.7	10.2	12.8	14.6	16.2
62	BON SECOUR	6.1	7.7	11.6	14.1	16.0
63	OYSTER BAY	6.4	8.2	12.3	14.1	15.8
64	FORT MORGAN	4.7	7.0	9.5	12.2	14.1
65	BEACH CLUB, BAY SIDE	4.3	6.5	9.5	12.4	14.4
66	BEACH CLUB, GULF SIDE	5.7	7.7	9.6	12.5	14.2
67	PILOT TOWN	4.6	6.5	9.4	12.3	14.5
68	GULF PLANTATION, BAY SIDE	5.6	8.0	10.1	12.1	14.5
69	GULF PLANTATION, GULF SIDE	5.8	8.5	10.5	12.6	14.9
70	GASQUE	6.4	9.4	12.2	14.1	15.4
71	PINE BEACH, GULF SIDE	5.7	8.5	11.1	13.1	15.7
72	PINE BEACH/LITTLE LAGOON	2.5	8.8	11.0	13.1	15.8
73	LITTLE LAGOON PASS	5.7	8.4	11.5	13.6	16.2
74	LITTLE LAGOON	3.1	8.8	12.0	14.0	16.4
75	GULF SHORES	5.8	8.5	11.7	14.0	16.6
76	ROMAR BEACH	5.7	8.5	11.4	14.0	16.8
77	PERDIDO PASS	5.7	8.3	11.2	14.0	16.9
78	ORANGE BEACH	5.3	8.5	11.9	14.5	17.3
79	JOSEPHINE	4.3	7.2	11.6	14.4	17.2
80	WOLF BAY @ I.C.W.	4.7	8.0	11.5	15.7	18.6
81	MIFLIN	5.3	8.1	12.2	17.9	22.0
82	WOLF BAY @ HWY 20 BRIDGE	5.0	8.1	11.6	14.7	17.5
83	PERDIDO BEACH	4.7	6.9	11.5	14.7	17.1
84	ONO ISLAND	4.4	7.9	11.3	14.1	17.1
85	TARKLIN BAY	4.9	6.9	11.5	13.8	16.4
86	PARADISE BEACH	5.2	7.4	10.8	14.1	17.5
87	MILLVIEW	5.5	7.7	10.9	13.8	17.1
88	PERDIDO RIVER ENTRANCE	5.5	7.8	11.1	14.2	17.5
89	SEMINOLE	5.6	8.1	11.1	13.6	15.8
90	I-10 @ PERDIDO RIVER (STATE LINE)	99.9	7.7	9.0	10.6	12.0

TROPICAL CYCLONE ADVISORY

Tropical cyclone advisories, produced by the National Hurricane Center every six hours, give the measured distance in nautical miles of the 34-knot (approximately 40 miles per hour), 1-minute sustained wind speed (tropical storm) from the eye of an approaching hurricane. These distances are given for the four quadrants of the storm (i.e., northwest, northeast, southeast, southwest). Forecasts of these distances for 12, 24, 36, 48, and 72 hours into the future are also given. The largest radius listed should be used for the pre-landfall hazard distance in evacuation decision-making. Further discussion of the application of the radius of tropical storm winds to hurricane evacuation decision-making is contained in Chapter 7, Decision Tools.

WAVE EFFECT



The SLOSH model does not provide data concerning the additional heights of waves generated on top of the still-water storm surge. Generally, waves do not add significantly to the area flooded and have little effect on the number of people that will be required to evacuate. Wave phenomena under hurricane conditions are not well understood, but it is believed that maximum wave heights occur near the time of landfall. Immediately along the coastline of very large sounds and estuaries, waves can increase the expected still-water depth by one-third or more. Due to the presence of barriers such as structures, dunes, or vegetation, the waves break and dissipate a tremendous amount of energy within a few hundred yards of the coastline. Buildings within that zone that are not specifically designed to withstand the forces of wave action are often heavily damaged or destroyed.

For evacuation planning purposes, it is perhaps more important to consider potential wave effects for less than sustained tropical storm winds. If wave heights above theoretical still-water levels exceed the elevations of roads, bridges, or other critical areas near the coastline, evacuation could be curtailed sooner than expected, increasing the pre-landfall hazards distance. Evacuation planners should be aware that low-lying sections of highway could be subject to some wave action and over-wash prior to the arrival of sustained tropical storm winds, especially with the coincidental occurrence of astronomical high tide.

HURRICANE WINDS

After hurricane Hugo in North Carolina and Andrew in south Florida it became apparent that storm surge was not the only life-threatening feature of hurricanes. Destructive hurricane force winds and tornadoes effected many inland counties as far as 100 miles from the coast. Studies by the National Hurricane Center (NHC) have resulted in modifying the Tropical Cyclone Advisory to include additional information to help inland counties prepare for threatening high wind conditions. An inland wind analysis option is included in the new HurrWin95 software program to assist inland communities in estimating when damaging winds might hit their county. The inland wind analysis should be used ONLY A FEW HOURS before the hurricane makes landfall. This is when the NHC track and wind-field forecast errors are relatively low.

FRESHWATER FLOODING

Amounts and arrival times of rainfall associated with hurricanes are highly unpredictable. For most hurricanes, rainfall begins near the time of arrival of sustained tropical storm winds and generally reaches maximum rainfall rates as the center passes by. Unrelated weather systems in advance of the hurricane can also contribute significant rainfall amounts within a basin. The 100-year floodplain boundaries for each county are shown on the National Flood Insurance Rate Maps (FIRM) which are published by the Federal Emergency Management Agency (FEMA)

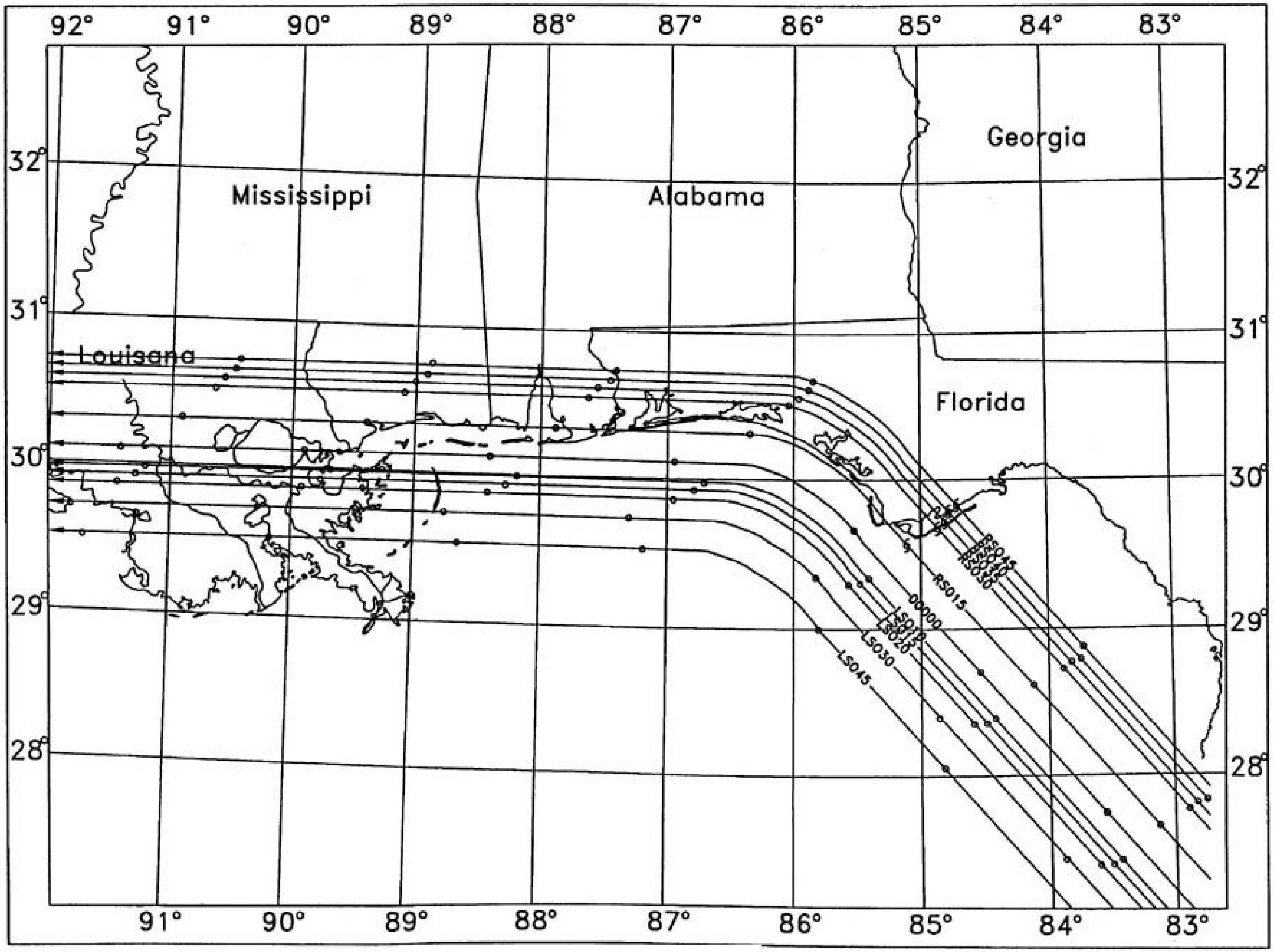


Plate 1 Hypothetical Hurricane Tracks heading West

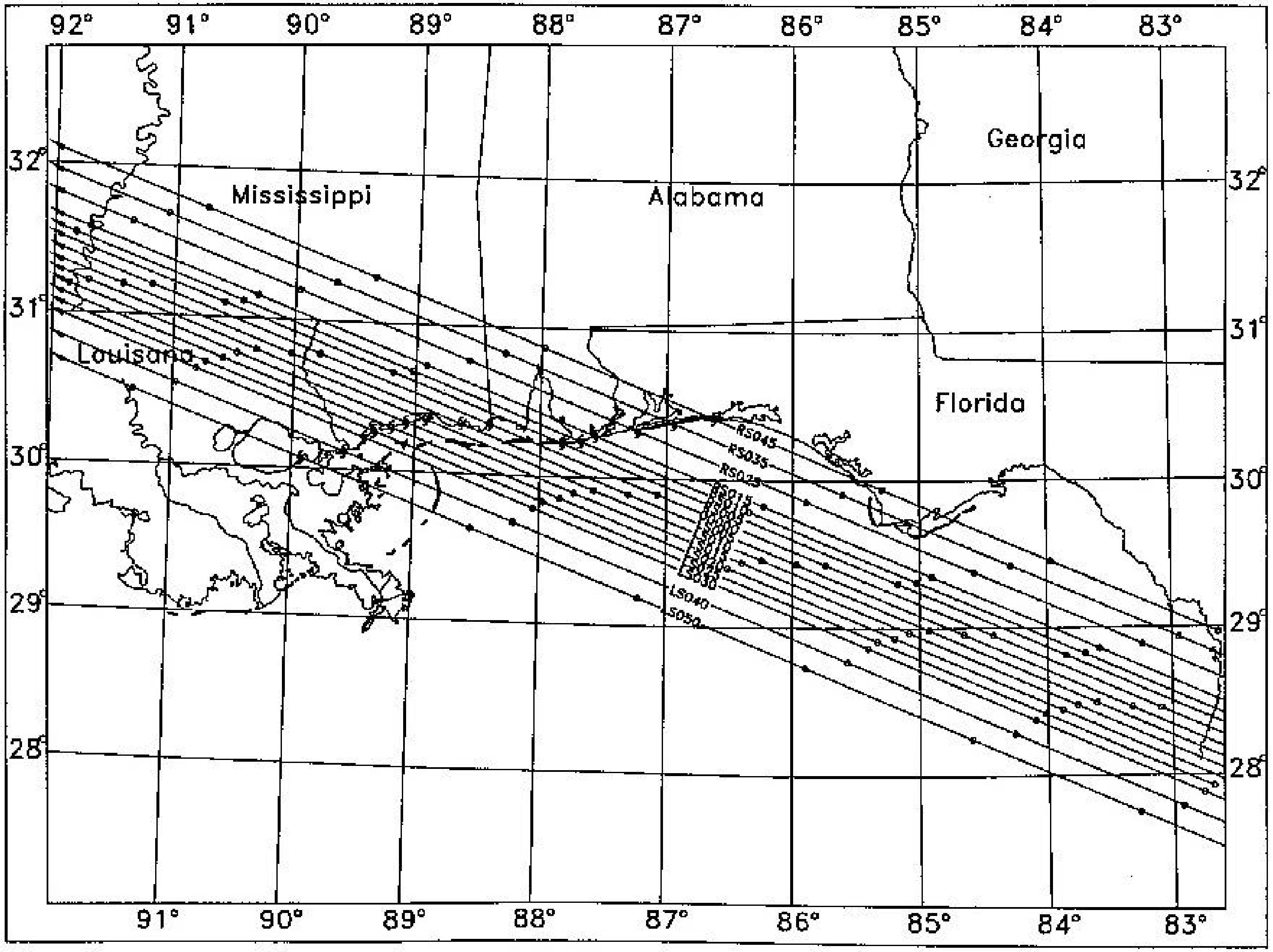


Plate 2 Hypothetical Hurricane Tracks heading West-northwest

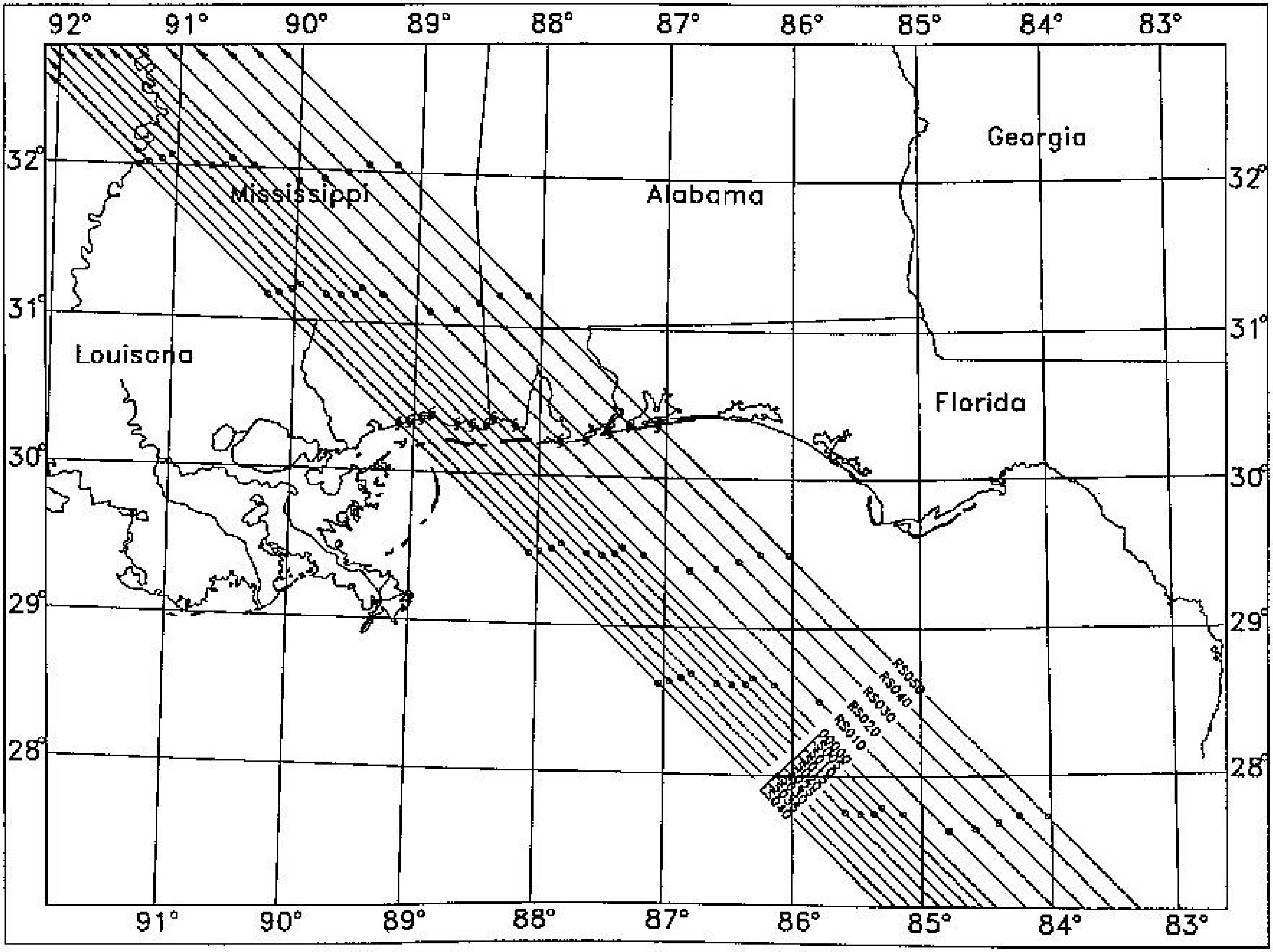


Plate 3 Hypothetical Hurricane Tracks heading Northwest

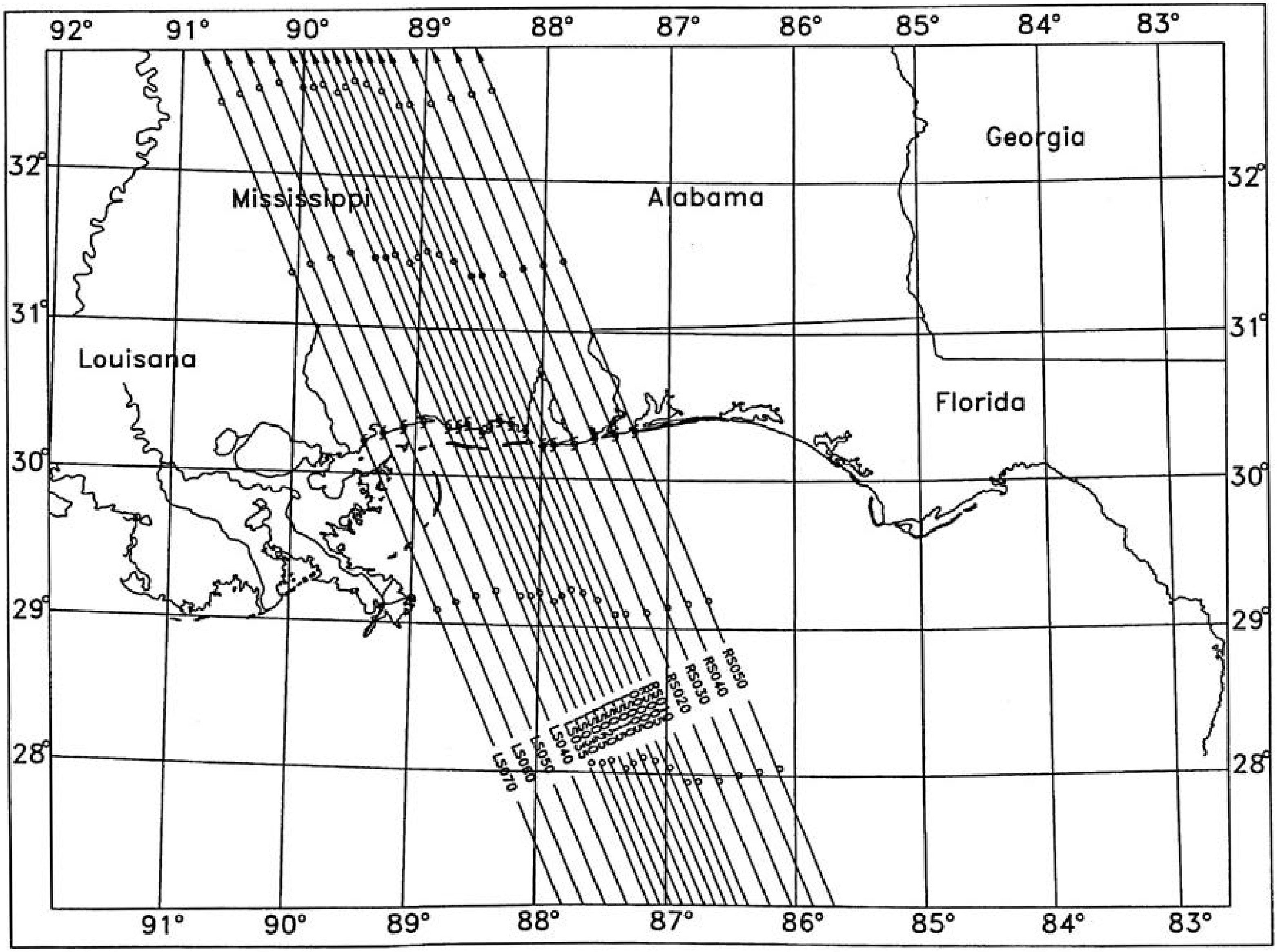


Plate 4 Hypothetical Hurricane Tracks heading North-northwest

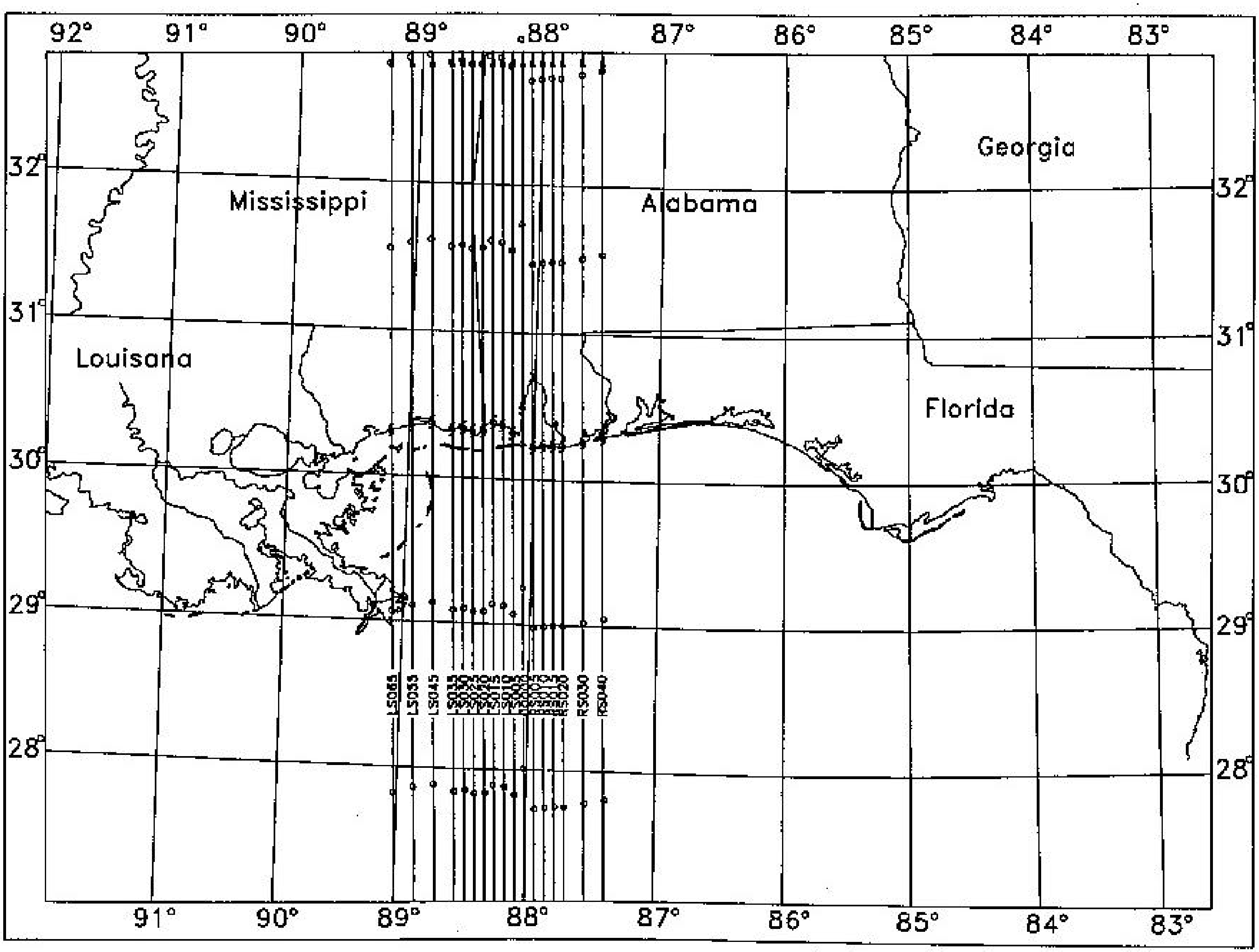


Plate 5 Hypothetical Hurricane Tracks heading North

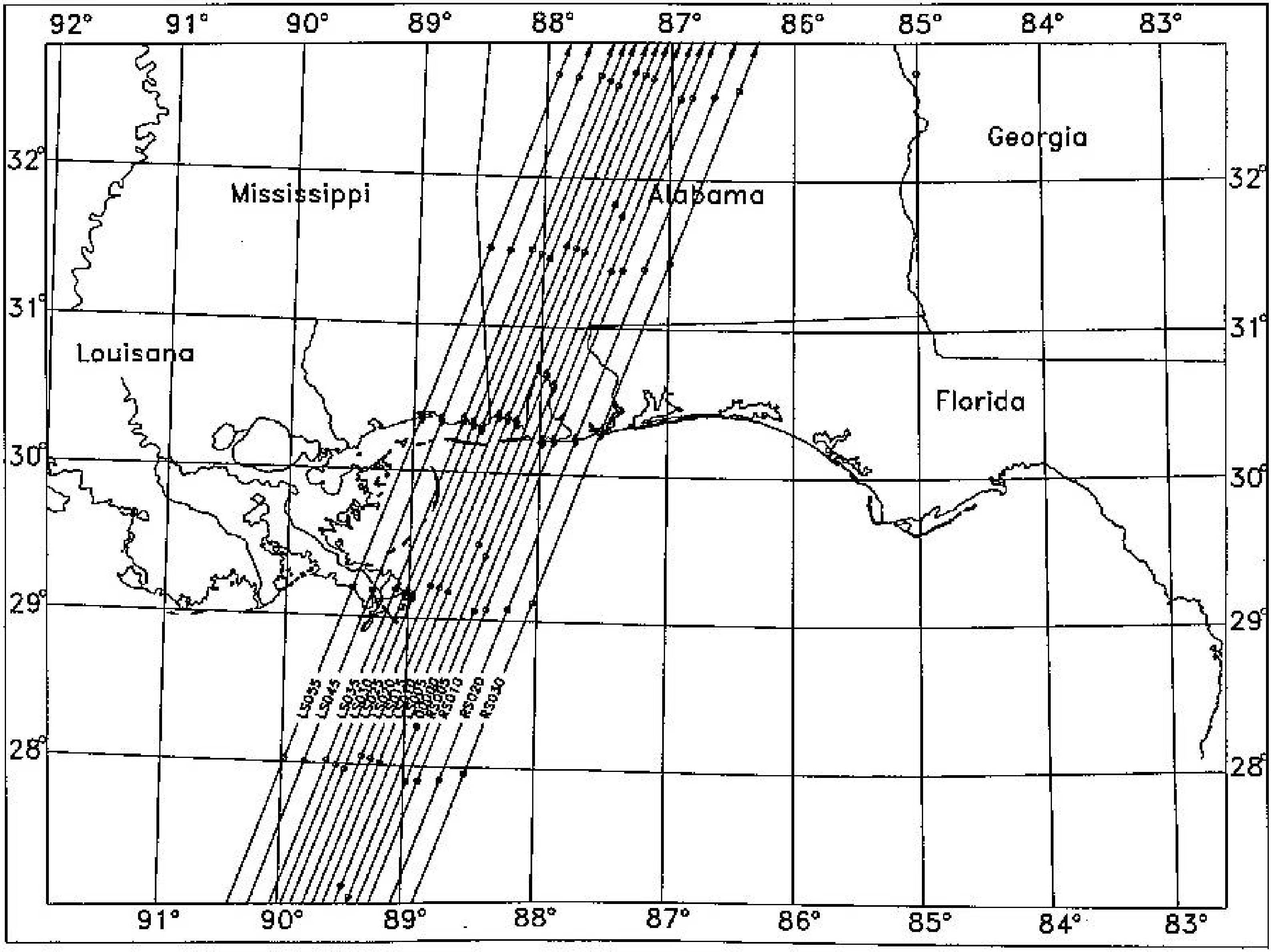


Plate 6 Hypothetical Hurricane Tracks heading North-northeast

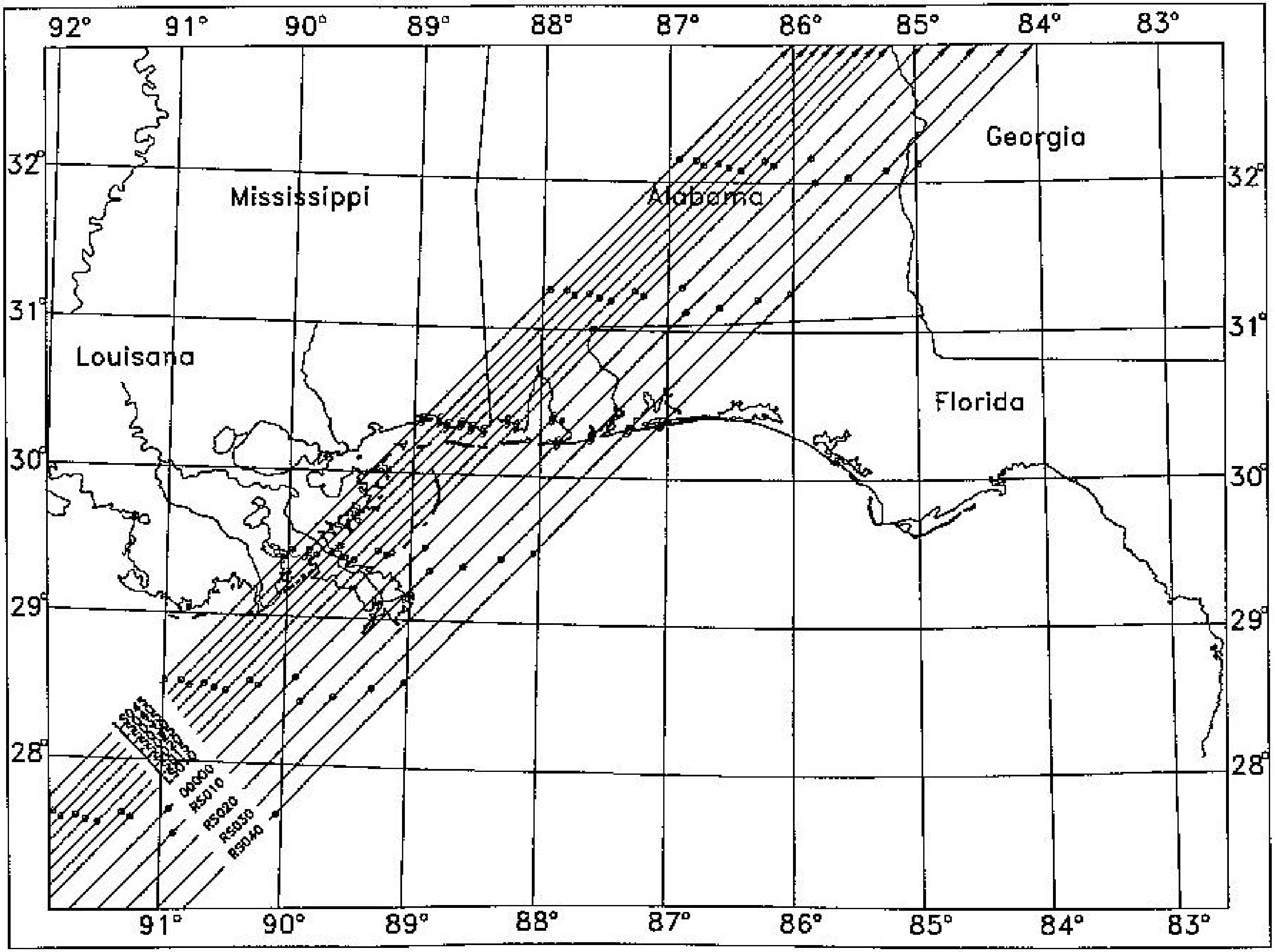


Plate 7 Hypothetical Hurricane Tracks heading Northeast

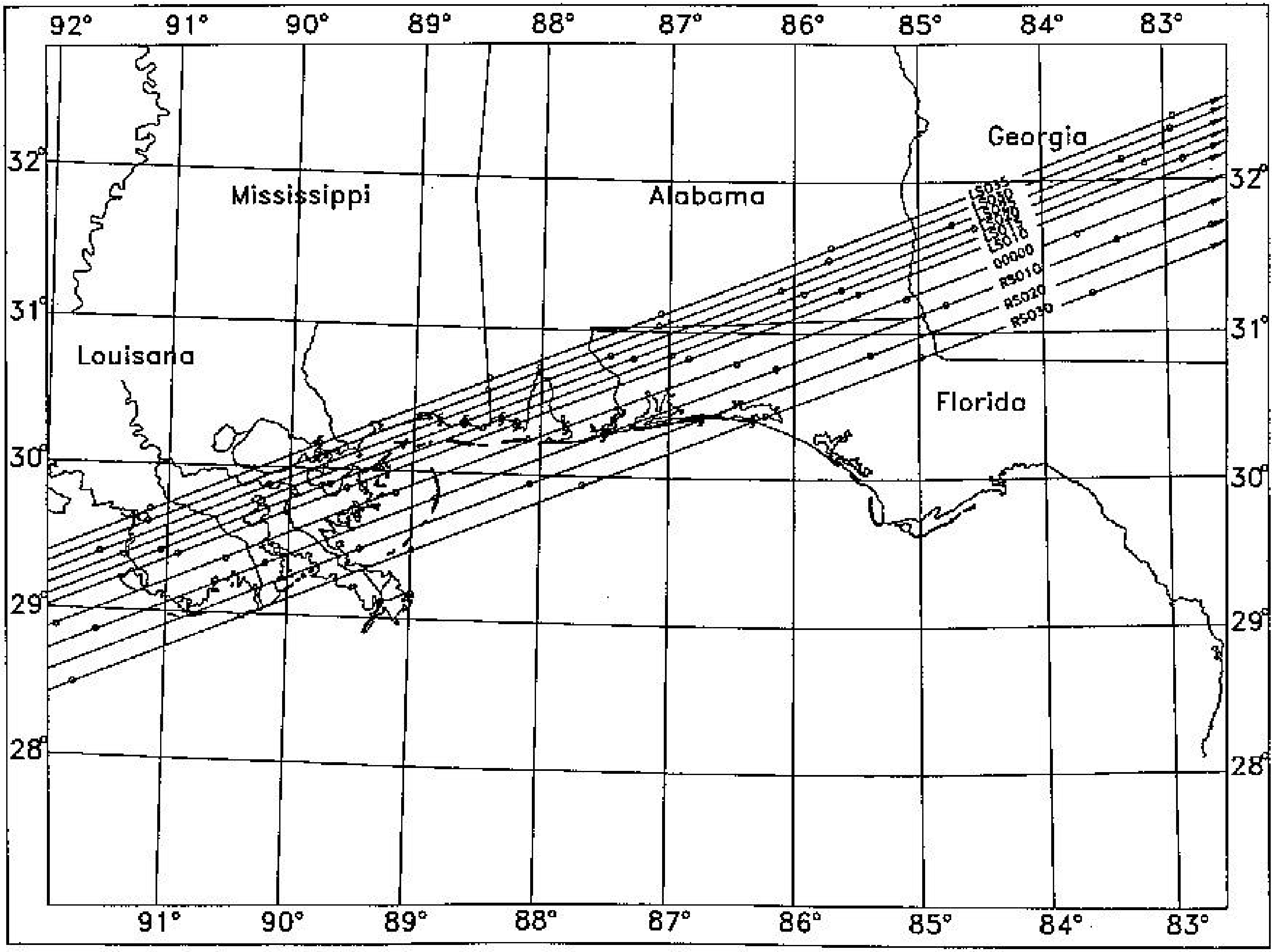


Plate 8 Hypothetical Hurricane Tracks heading East-northeast

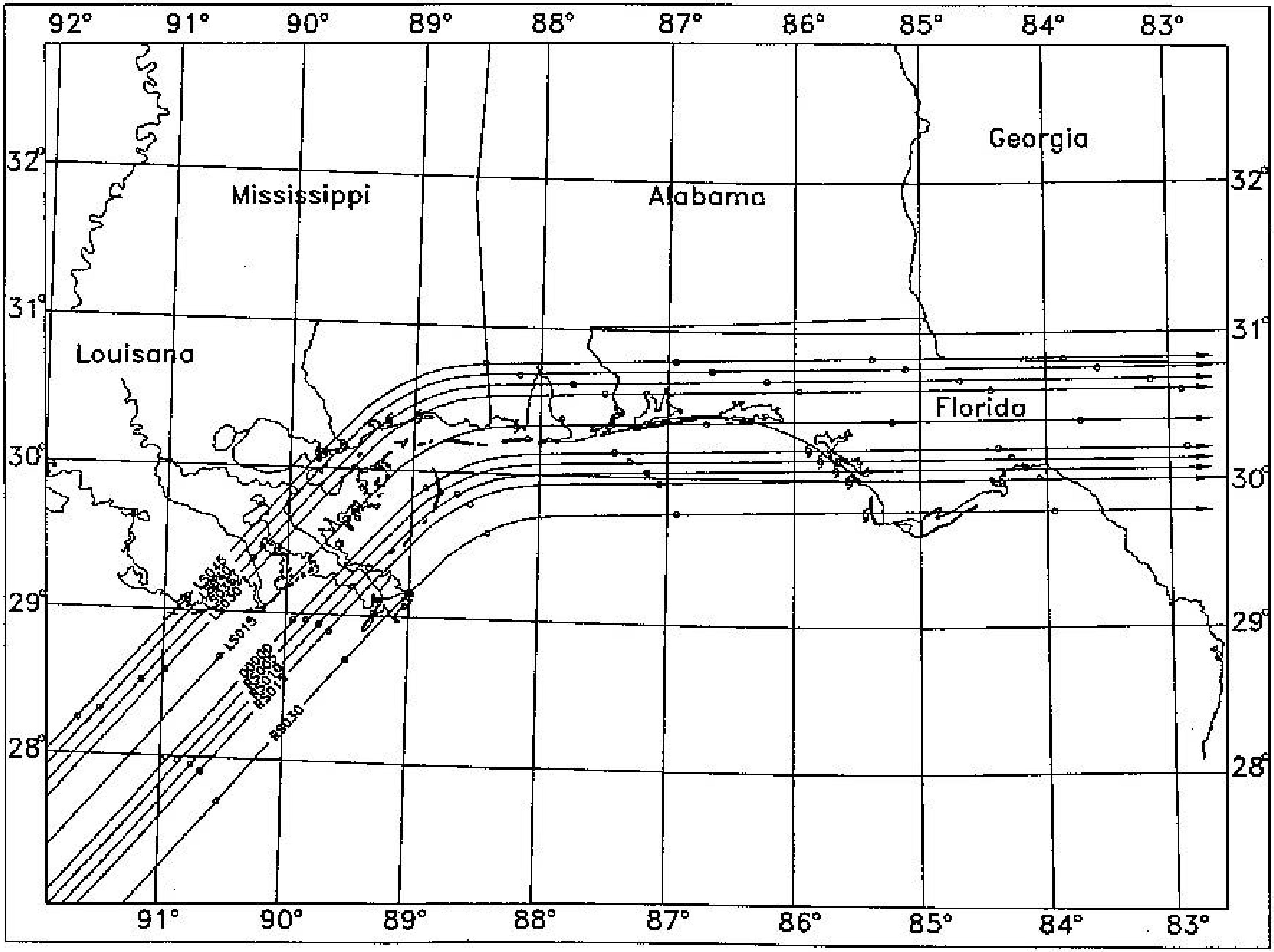


Plate 9 Hypothetical Hurricane Tracks heading East